

## II.4-TATUM TATUM COEFFICIENT ROUTING

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### Introduction

Tatum coefficient routing is a numerical non-storage method of routing a hydrograph through a channel.

Unlike storage or dynamic routing Tatum coefficient routing is not closely tied to the physical processes or river hydraulics within a reach. Arbitrary coefficients at specific ordinates are used to route flow. These coefficients are usually derived empirically through examination of inflow and outflow hydrographs.

The method of Tatum coefficient routing described here is similar to the successive average-lag method of routing developed by Tatum in 1940 (see Linsley et. al., 1949 and Lawlorm, 1964). However it is considerably more flexible than the original method proposed by Tatum. By using several discharge layers with a unique set of coefficients for each layer it is possible to apply varying amounts of attenuation and/or lag to different ranges of flow. The name Tatum has been retained because this method of routing is usually referred to as Tatum coefficient routing by those who use it.

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### Procedure

Tatum coefficient routing applies coefficients to an instantaneous inflow hydrograph defined at specific ordinates. The coefficients determine what percentage of the inflow at a particular ordinate will appear as routed discharge at the corresponding ordinate and subsequent ordinates. When multiple layers are used the inflow per layer does not always represent total inflow. It represents that portion of inflow pertinent to a specific layer or that portion that

falls within the range of flow assigned to a layer. Inflow for a specific layer never exceeds the upper discharge limit for that layer minus the lower discharge limit for that layer.

The Tatum coefficient routing equation can be expressed as:

$$O_{t\ell} = c_{1\ell} * I_{t\ell} + c_{2\ell} * I_{(t-1)\ell} + \dots + c_{N\ell} * I_{(t-N+1)\ell}$$

or as

$$O_{t\ell} = \sum_{i=1}^N c_{i\ell} * I_{(t-i+1)\ell}$$

where  $O_{t\ell}$  is the instantaneous outflow for layer  $\ell$  at time  $t$   
 $c_{i\ell}$  is one of  $N$  Tatum coefficients per layer  
 $I_{(t-i+1)\ell}$  is that portion of instantaneous inflow appropriate for a layer

Total outflow is the sum of instantaneous outflow for all of the layers expressed as:

$$O_t = \sum_{\ell=1}^L O_{t\ell}$$

or as

$$O_t = \sum_{\ell=1}^L \sum_{i=1}^N c_{i\ell} * I_{(t-i+1)\ell}$$

where  $L$  is the number of layers used to route flow

The following are examples of how Tatum routing works. Consider a channel reach AB, where discharge ( $Q$ ) at A must be routed downstream to B. Three discharge layers have been determined for the reach from historical records. The coefficients for these layers are:

| Layer | Coefficients |     |      |      |     |     | For                                |
|-------|--------------|-----|------|------|-----|-----|------------------------------------|
| 1     | 0.0          | 0.8 | 0.2  |      |     |     | $Q \leq 200$ CMS                   |
| 2     | 0.0          | 0.5 | 0.25 | 0.25 |     |     | $200 \text{ CMS} < Q \leq 400$ CMS |
| 3     | 0.0          | 0.1 | 0.2  | 0.4  | 0.2 | 0.1 | $Q > 400$ CMS                      |

Table 1 [Bookmark] has 6 days of 6 hour instantaneous inflow values for the reach and shows how each layer is routed and how each layer contributes to outflow for the reach at B. Flow per layer is routed diagonally across and down the table. Routed flows are then summed horizontally to determine instantaneous outflow for each of the 6 hour ordinates. Figure 1 [Bookmark] illustrates the inflow hydrograph and the outflow hydrograph which result from routing in this manner. The number of carryover positions per layer is one less than the number of coefficients within the layer.

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## Comments on the Use of Tatum Coefficient Routing

There is no specific limit to the number of discharge layers that can be used for a reach or to the number of coefficients that can be used within a layer. Likewise there is no set width for discharge layers. One layer may be perfectly adequate for some routing situations. Other situations may require three or four layers. The number of width of layers should be related to physical characteristics of the reach where this is possible. An important thing to remember is that Tatum coefficient routing is a rather unsophisticated method of routing. The inherent flexibility of the procedure does not imply that Tatum coefficient routing could be applied successfully to most routing situations. In general Tatum coefficient routing should only be applied to reaches where other routing procedures have not been developed and where Tatum coefficients have been used successfully.

The sum of all the coefficients within a layer is usually equal to 1.0. If coefficients within the layer do not sum to 1.0 then either a loss or gain of flow will occur in routed discharge at the downstream flow-point. Generally this would be undesirable. However the mechanism for applying either a percentage gain or a percentage loss of flow during the routing operation does exist.

Tatum coefficient routing may be used to apply a constant lag to flow when the desired lag is equal to or is a multiple of the ordinate spacing. For example, a constant lag of 12 hours could be applied to an inflow hydrograph with ordinate spacing of 6 hours by using one coefficient layer with coefficients of 0.0, 0.0 and 1.0. However a more direct approach would be to use the NWSRFS lag algorithm to apply lag. This would permit constant lag of any duration, as well as variable lag to be used. Attenuation could then be applied with Tatum coefficients.

Tatum coefficient routing has the ability to variably attenuate flow in a reach because of different coefficients for different layers of flow. Therefore, this method can be used at a point to account for attenuation in a channel system above a headwater gage.

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## References

Lawler, E.A., 1964: 'Flood Routing', sec. 25-II in V.T. Chow (ed.), Handbook of Applied Hydrology, McGraw-Hill, New York.

Linsley, R.K., Kohler, M.A. and Paulhus, J.L.H., 1949: Applied Hydrology, McGraw-Hill, New York.

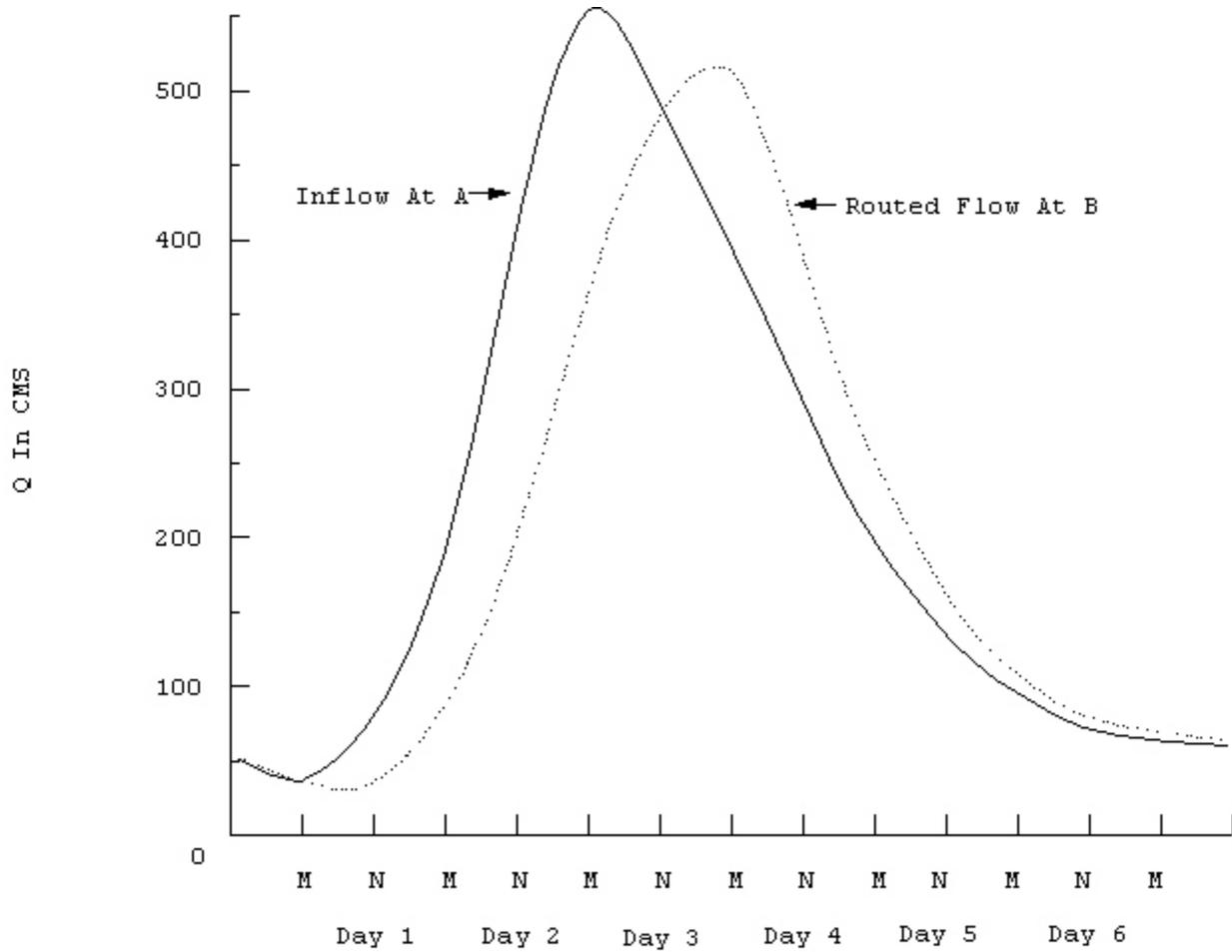
Tatum, F.E., 1940: 'A Simplified Method of Routing Flood Flows through Natural Valley Storage', unpublished memorandum, U.S. Engineers Office, Rock Island, Illinois.

Table 1. Tabular example of Tatum Routing

| Routing Period | Inflow at A CMS | Layer 1 Coefficients |     |       | Layer 2 Coefficients |     |       |      | Layer 3 Coefficients |     |      |      |      | Outflow at B CMS |       |       |
|----------------|-----------------|----------------------|-----|-------|----------------------|-----|-------|------|----------------------|-----|------|------|------|------------------|-------|-------|
|                |                 | 0.0                  | 0.8 | 0.2   | 0.0                  | 0.5 | 0.25  | 0.25 | 0.0                  | 0.1 | 0.2  | 0.4  | 0.2  |                  | 0.1   |       |
| Day 1          | 12 M            | 40.0                 | 0.0 | 33.6* | 9.0*                 |     |       |      |                      |     |      |      |      |                  | 42.6  |       |
|                | 6 AM            | 72.0                 | 0.0 | 32.0  | 8.4*                 |     |       |      |                      |     |      |      |      |                  | 40.4  |       |
|                | 12 N            | 118.0                | 0.0 | 57.6  | 8.0                  |     |       |      |                      |     |      |      |      |                  | 65.6  |       |
|                | 6 PM            | 170.0                | 0.0 | 94.4  | 14.4                 |     |       |      |                      |     |      |      |      |                  | 108.8 |       |
|                | 12 M            | 240.0                | 0.0 | 136.0 | 23.6                 | 0.0 |       |      |                      |     |      |      |      |                  | 159.6 |       |
| Day 2          | 6 AM            | 314.0                | 0.0 | 160.0 | 34.0                 | 0.0 | 20.0  |      |                      |     |      |      |      |                  | 214.0 |       |
|                | 12 N            | 396.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 57.0  | 10.0 |                      |     |      |      |      |                  | 267.0 |       |
|                | 6 PM            | 486.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 98.0  | 28.5 | 10.0                 | 0.0 |      |      |      |                  | 336.5 |       |
| Day 3          | 12 M            | 550.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 100.0 | 49.0 | 28.5                 | 0.0 | 8.6  |      |      |                  | 386.1 |       |
|                | 6 AM            | 517.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 100.0 | 50.0 | 49.0                 | 0.0 | 15.0 | 17.2 |      |                  | 431.2 |       |
|                | 12 N            | 462.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 100.0 | 50.0 | 50.0                 | 0.0 | 11.7 | 30.0 | 34.4 |                  | 476.1 |       |
|                | 6 PM            | 410.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 100.0 | 50.0 | 50.0                 | 0.0 | 6.2  | 23.4 | 60.0 | 17.2             | 506.8 |       |
|                | 12 M            | 364.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 100.0 | 50.0 | 50.0                 | 0.0 | 1.0  | 12.4 | 46.8 | 30.0             | 8.6   | 498.8 |
| Day 4          | 6 AM            | 322.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 82.0  | 50.0 | 50.0                 |     |      | 2.0  | 24.8 | 23.4             | 15.0  | 447.2 |
|                | 12 N            | 284.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 61.0  | 41.0 | 50.0                 |     |      | 4.0  | 12.4 | 11.7             | 380.1 |       |
|                | 6 PM            | 248.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 42.0  | 30.5 | 41.0                 |     |      |      | 2.0  | 6.2              | 321.7 |       |
|                | 12 M            | 215.0                | 0.0 | 160.0 | 40.0                 | 0.0 | 24.0  | 21.0 | 30.5                 |     |      |      |      | 1.0              | 275.5 |       |
| Day 5          | 6 AM            | 184.0                | 0.0 | 160.0 | 40.0                 |     | 7.5   | 12.0 | 21.0                 |     |      |      |      |                  | 240.5 |       |
|                | 12 N            | 156.0                | 0.0 | 147.2 | 40.0                 |     |       | 3.8  | 12.0                 |     |      |      |      |                  | 203.0 |       |
|                | 6 PM            | 130.0                | 0.0 | 124.8 | 36.8                 |     |       |      | 3.0                  |     |      |      |      |                  | 165.4 |       |
|                | 12 M            | 114.0                | 0.0 | 104.0 | 31.2                 |     |       |      |                      |     |      |      |      |                  | 135.2 |       |
| Day 6          | 6 AM            | 100.0                | 0.0 | 91.2  | 26.0                 |     |       |      |                      |     |      |      |      |                  | 117.2 |       |
|                | 12 N            | 88.0                 | 0.0 | 80.0  | 22.3                 |     |       |      |                      |     |      |      |      |                  | 102.8 |       |
|                | 6 PM            | 77.0                 | 0.0 | 70.4  | 20.0                 |     |       |      |                      |     |      |      |      |                  | 90.4  |       |
|                | 12 M            | 67.0                 | 0.0 | 61.6  | 17.6                 |     |       |      |                      |     |      |      |      |                  | 79.2  |       |

\* = routed discharge carryover

Figure 1. Example of Tatum Routing



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